EVALUATION OF ORGANIC FERTILIZERS AS INTEGRATED NUTRIENT MANAGEMENT PRACTICE IN TOMATO (*Solanum lycopersicum* L.)

SYNOPSIS

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By

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1. Title: EVALUATION OF ORGANIC FERTILIZERS AS INTEGRATED NUTRIENT MANAGEMENT PRACTICE IN TOMATO (*Solanum lycopersicum* L.)

2. Introduction

The Tomato (*Solanum lycopersicum* L.), which has the chromosomal number 2n=24 and belongs to Solanaceae family, is a significant crop that is grown extensively over the world due to its high nutritional value. It also goes by the name "poor man's orange." Due to its great nutritional value and higher production under various climatic conditions, it plays a significant economic function. The crop has a high nutritional requirement for greater yield and better quality, yet total reliance on inorganic fertilizer leads to lower profits because it is more expensive. Lycopene, which is found in tomatoes and lowers the incidence of prostate cancer, as well as various vitamins A, B, and C, are also abundant in tomatoes. Additionally, it has antioxidants and minerals that are beneficial to human health. It can be used in processed forms like ketchup, puree, powder, paste, etc., and can be consumed raw or cooked (Rani and Tripura, 2021). It is primarily planted in backyard gardens for fresh food consumption. Tomato is cultivated worldwide in both protected and uncovered situations, however uncovered cultivation is relatively restricted due to low summer temperatures and winter frost damage. They are cultivated in polyhouses for successful year-round farming.

In India and global output, tomato comes in second place to potato. Indian states with significant tomato production include Punjab, Haryana, Maharashtra, Uttar Pradesh, Karnataka and Bihar. In India, 20,336 (000 MT) of Tomato are produced on 841 (000 ha) of land. It is farmed in Himachal across an area of 14 (000 ha), producing 577 MT (Ministry of Farmers and Agriculture Welfare, 2021–2022). Because of its high mineral and vitamin content, it is one of Himachal Pradesh's most important vegetable crop. Due to the huge diversity of terrain, climatic conditions, soil, etc., which is required for increased

production, the Indian subcontinent is capable of producing Tomato in large quantity. Vegetable production in India is low as compared to other industrialized nations despite annual productivity and production increases in the vegetable sector. This is because Indian farmers choose cash crops over vegetable crops because they yield higher profits (Rani and Tripura, 2021).

The emphasis of integrated nutrition management is on the necessity of using more fertilizers, either organic or inorganic, that include nutrients. Its objective is to maximize the utilization of synthetic and organic soil nutrients to maintain soil fertility for future generations and boost agricultural yield (FAO, 1995). INM increases crop yields by 8–15% compared to traditional methods. Its main goal is to give crops with neutral nutrients and improve soil fertility for long-term high yield (Meena and Reddy, 2021). High nutrient usage efficiency is achieved under INM methods by reducing losses through leaching, volatilization, immobilization, runoff and emissions (Zhang et al. 2012). Rising living standards in rural regions, where the bulk of the poor live and get their food, are one of the primary problems confronted by agricultural planners and decision makers in the goal of a world without hunger and without poverty (Wheller and Braun, 2018). To reach the objective of ending hunger, crop production and productivity should be raised in light of the worrying global population growth and land scarcity. Management of soil fertility is crucial for boosting crop output. Farmers are applying more chemical fertilizers to improve soil fertility, which raises the cost of output (Panta and Parajulee, 2021).

Various nations are struggling to supply food free of chemicals because of their expanding populations. Due to the extensive use of synthetic fertilizers, which also deplete soil fertility and destroy important microbes, vegetable yield is dropping day by day. These chemicals are also harming our ecosystem (Diacono and Montemurro, 2010). Spraying pesticides on plants results in them immediately entering our food chain, which leads to a number of ailments that are hazardous to human health, including cancer, skin allergies, asthmatic issues, and others. People today prefer organic foods over conventional ones, which has led to the adoption of a variety of chemical free, eco-friendly organic manures in vegetable production, including FYM, compost, biofertilizers, vermicompost, and manures, among others. They'll maintain our environment while enhancing the health of the soil, plants, and people (Radhika and Savita, 2021). Additionally, organic fertilizer enhances the soil's nutritional availability, biological and chemical characteristics. Balanced fertilization is crucial to improving tomato production characteristics.

Farmyard manure contains 0.5% nitrogen, 0.2% phosphorus, 0.5% potassium and aids in improving soil fertility and plant growth by containing beneficial microorganisms that secrete growth regulators. It is a decomposing mixture of farm animal dung and urine. Vermicompost improves soil fertility, resulting in higher yields and higher quality, as well as increased nutritive value. It reduces soil

erosion and improves soil texture and structure. The earthworm *Eisenia fetida* is commonly used to convert organic waste into nutrient rich organic fertilizer (Garg and Sharma, 2017). It contains macronutrients as well as micronutrients, such as nitrogen (1.6%), potassium (0.7-0.8%), zinc, manganese and phosphorous (0.7%). (Kumari and Srivastava, 2007).

The use of biofertilizers in conjunction with inorganic fertilizer may result in a higher yield and better quality of produce, allowing farmers to increase their profit margins. Biofertilizers contain living microorganisms that are both environmentally friendly and cost effective. They aid in atmospheric nitrogen fixation, phosphorous solubilization and plant growth hormone stimulation. It is suitable for use as manure and compost. Under favorable conditions, *Azotobacter* and *Azospirillum* are important bacteria that fix N, P and K. They can boost not only plant growth and development, but also production and productivity in a variety of areas. Plants benefit primarily from root development, increased water uptake, and nitrogen fixation. *Azotobacter* also secretes substances that aid in root growth, such as pantathonic acid and gibberellins. In addition, it secretes ammonia into the rhizosphere, which aids plant nutrient uptake (Narula and Gupta, 1986). Due to their low levels of solubility and mobility, phosphate solubilizing bacteria (PSB) are mostly used because they are difficult to access to vegetable crops and help to improve plant phosphate uptake in a variety of ways.

Keeping in view the present research program entitled "Evaluation of Organic Fertilizers as Integrated Nutrient Management practice in Tomato (*Solanum lycopersicum* L.)" will be conducted for two consecutive years (2023-24) for achieving the following objectives.

1. To identify the most suitable treatment combination(s) for growth, yield and other horticultural traits
2. To find out the treatment combination(s) having maximum nutrient status along with nutrient uptake

Knowledge Gap-

Presently the farmers are using expensive inorganic fertilizers to enhance their yield that sometimes result in health hazards. The farmers are deliberately using the inorganic fertilizers as they lack the knowledge about different organic fertilizers and biofertilizers. So, this study is going to bridge the gap of knowledge among the farmers where they are going to use different integrated nutrient management techniques in order to get good quality yield and better price. The use of organic fertilizers will also improve the soil health and provide health benefits.

3. Expected New Knowledge

Integrated Nutrient Management improves nutrient use efficiency by reducing the use of expensive inorganic fertilizers which enhances yield and fertilizer traces are left. The traces of inorganic nutrients

result in the health hazards of human beings. Keeping in view the health issues of consumers, the present study is framed with different organic fertilizers and their combinations. The result of this study is expected to provide Integrated Nutrient Management of the Tomato crop for good quality yield, to fetch best price. As the application of organic fertilizers improves the soil texture and provide long term benefit. The crop cultivated through this technology will be good for the health.

4. Review of Literature

4.1 Vegetative characters

Ramesh and Sikder, (2021) studied the integration of nutrient management standards for Tomato growth and yield in a Randomized Block Design. The results indicated that ½ recommended NPK + 50% FYM + 30% Vermicompost + 20% Poultry Manure gave best results for stem girth at the last harvest (14.85mm), minimum days first to flowering (27.46), number of truss out of each plant (20.59); plant height at last harvest (92.13cm) by treatment with recommended NPK; number of primary branches (7.38) from treatment with ½ recommended NPK + 50% FYM + 50% vermicompost and minimum days to the fruit maturity (58.31) from treatment with ½ recommended NPK + 50% FYM + 50% Vermicompost + PSB.

In an experiment, Mishra et al. (2019) sought to understand how Tomato manage their organic nutrient intake. In RBD, nine treatments were reproduced three times. The results proved that the treatment with the prescribed dose of fertilizer had the most branches per plant (7.60) and leaves per plant (42.20), which was comparable to the treatments with FYM @ 20 t/ha and Vermicompost @ 5 t/ha. Under FYM @20t/ha, a maximum plant height of 38.78 cm was specified.

In order to determine the influence of Integrated Nutrient Management on Tomato growth characteristics and soil nutrient status in naturally ventilated polyhouses at MPUAT, Udaipur, Rajawat et al. (2019) undertook a study. Treatment T_8 with 75% organic management + 25% inorganic fertilizers showed the greatest results in terms of highest plant height at 90 DAT (183.40 cm) and plant height at final harvesting stage (245.18 cm). The greatest results were reported for maximum leaf area (89.24cm^2) and stem diameter in treatment T_2 with 100% RDF + biofertilizers (1.46cm). The treatment that produced the highest number of branches per plant (8.69) was 100% vermicompost + biofertilizers.

At G.B.P.U.A.T., Pantnagar, Uttrakhand, Kamal et al. (2018) did a study titled the influence of Biofertilizers on Tomato (*Lycopersicum esculentum* Mill.) growth and yield. The findings showed that *Azospirillum* + 75%Nitrogen + approved doses of Phosphorous and Potassium resulted in the largest plant height (121.0cm) at final harvest and the shortest number of days to first blooming (69.67). The treatment with *Azotobacter* and RDF of fertilizer demonstrated the highest maximum leaf area index (3.41), and the

plot treated with VAM and NPK at the indicated dose recorded the highest maximum stem diameter (15.89mm).

Meena et al. (2017) carried out an experiment to know the impact of biofertilizers on the growth, yield, and quality of the PusaSheetal variety of Tomato (*Lycopersicum esculentum* Mill.).Treatment with 75% RDF + 25% FYM + *Azospirillum* recorded the best result for plant height (16.32, 26.29 and 30.52cm) which is significant over the control at 30, 60 and 90 DAT; number of branches per plant (4.40, 9.56 and 13.08) varied significantly at 30, 60 and 90 DAT; number of flower clusters per plant (9.13); number of flowers per plant (31.43); minimum days to first flowering (41.10); minimum days to 50% flowering (49.09) and minimum days to fruit set (67.35).

Gopinathan and Prakash (2014) studied the effect of Vermicompost enriched with Biofertilizers on the productivity of Tomato (*Lycopersium esculentum* Mill.) and the results indicated that maximum plant height (119cm), number of leaves (17.3), number of branches (5) and length of root (50.3cm) was recorded from the soil treated with Vermicompost and *Azospirillum*.

Manohar et al. (2013) conducted a field experimentduring summer season entitled Integrated Nutrient Management in Tomato (*Lycopersiconesculentum* Mill) cv. Rocky at College of Agriculture, Jobner (Jaipur). The results indicated that among different doses of Farm Yard Manure, maximum plant height (60.98cm), the number of primary branches per plant (6.79) and opening of first flower after transplanting (30.46 days) was observed by FYM @ 20t/ha whereas, 100% RDF (NPK) + B + Zn gave best results for vegetative characters like plant height (60.79cm), number of primary branches per plant (6.79) and opening of first flower after transplanting (30.46 days).

In the rabi and kharif seasons, Pandey and Chandra (2012) conducted research on the effects of Integrated Nutrient Management on Tomato productivity in the Chandauli area of Uttar Pradesh. The maximum plant height (90.31 cm and 99.41 cm), main branches (7.15 cm and 7.77 cm), and root length (32.85 cm and 40.33 cm) were all recorded under the treatment Farm Yard Manure (10t/ha) + N:P:K (150:80:60 kg/ha) by immersing roots of the seedlings in 1% *Azotobacter* and 20ppm ferrous ammonium sulphate.

In order to understand how Integrated Nutrient Management affects Tomato growth, yield, and quality in the trans Himalayan, Sepat et al. (2012) conducted an experiment. They carried out the experiment in Leh and Ladakh during two kharif seasons. According to the findings, treatment with 100% NPK + FYM + *Azotobacter* produced the greatest results for plant height (79.00cm), leaf area (218.3cm^2), branches per plant (7.80), and leaf per branch (18.70).

4.2 Quantitative characters

Manickam et al. (2022) investigated how various nutrient sources affected on productivity, profitability and Tomato (*Solanum lycopersicum* L)quality at Department of Sustainable Organic Agriculture T.N.A.U. Coimbatore, Tamil Nadu. The results of the study revealed that maximum fruit weight (57.7g), fruit girth (50.5mm) and fruit yield (25794kg/ha) was recorded best under treatment with FYM 25t/ha + Azophos @ 2kg/ha + RDF.

Ramesh and Sikder, (2021) carried out an experiment entitled standardization of Integrated Nutrient Management for growth and yield of Tomato. Maximum fruit weight (127.71g), yield per plant (4.49kg) and yield per hectare (79.62t/ha) proved best for treatment with ½ recommended NPK + 50% FYM + 30% Vermicompost + 20% poultry manure. Number of fruits per truss (6.23) was best under ½ recommended NPK + 50% FYM + 50% vermicompost and number of fruits per plant (51.12) gave best results for treatment with ½ recommended NPK + 50% FYM + 30% vermicompost + 20% poultry manure + neem cake.

Mishra et al. (2019) at the Orissa University of Agriculture and Technology, Orissa, completed a study to determine the impact of organic nutrient management in tomato. The study, which spanned two years, found that FYM @20t/ha as a basal dose resulted to the highest fruit weight per plant (762.50g) and quantity of fruits per plant (16.07).

The impact of Integrated Nutrient Management on the growth characteristics and soil nutrient status of Tomato grown in naturally ventilated polyhouses was the subject of an experiment done by Rajawat et al. (2019) at MPUAT, Udaipur. Results showed that the 100% Vermicompost + Biofertilizers treatment combination had given the best performance for traits like maximum clusters per plant (8.08) and fruits per cluster (6.60).

The Department of Vegetable Science at G.B.P.U.A.T., Pantnagar, Uttar Pradesh, was the site of an experiment by Kamal et al. (2018) titled the effect of Biofertilizers on growth and yield of Tomato (*Lycopersicon esculentum* Mill). It was shown that treatments using *Azotobacter* at the prescribed dose of NPK recorded the highest maximum values for the number of fruits per plant (48.23), the number of primary branches (11.99), and fruit yield (693.32q/ha).

Meena et al. (2017) studied the impact of Biofertilizers on growth, yield and quality of Tomato (*Lycopersicon esculentum* Mill.) cv. PusaSheetal and found that maximum value of average number of fruits per plant (14.07), average fruit diameter (63.61 mm), average fruit weight (64.94g), fruit yield per plant (0.92 kg), fruit yield per plot (14.09 kg) and yield per hectare (370.1 q) performed best under treatment combination 75% RDF + 25% FYM + *Azospirillum.*

Tekale et al. (2017) carried out a study entitled Integrated Nutrient Management (INM) on nutrient availability, uptake and yield of Tomato (*Lycopersiconesculentum* Mill.) cv. "Gujarat Tomato 2" during rabi season at Regional Horticultural Research Station, N.A.U, Navsari, Gujarat and found that treatment with FYM 20t/ha + 100% RDF NPK gave best results for parameters like fruit yield per plant (1.54kg) and fruit yield per plot (30.71kg).

Manohar et al. (2013) conducted a study Integrated Nutrient Management in Tomato (*Lycopersiconesculentum* Mill) cv. Rocky during the summer season at College of Agriculture, Jobner, Jaipur. The studies revealed that FYM@20t/ha gave maximum number of picking (8.75), average number of fruit per plant (26.80), average fruit weight (51.33g), yield per plant (1.53kg) and total yield (359.24q/ha). Among inorganic fertilizers treatment with 100% RDF (NPK) + B + Zn recorded best results for characters like number of picking (8.42), average number of fruit per plant (26.45), average fruit weight (51.98g), yield per plant (1.51kg) and total yield (356.68q/ha).

Pandey and Chandra, (2012) studied the impact of Integrated Nutrient Management on Tomato yield under farmers field condition at Chandauli district of Uttar Pradesh. The results revealed that average fruit weight per plant (94.80g and 96.00g) and maximum marketable yield (955.0q/ha and 1025.0q/ha) respectively for both rabi and kharif season was observed under treatment FYM (10t/ha) + NPK (150:80:60 kg/ha) by dipping seedling roots with 1% *Azotobacter* and 20ppm ferrous ammonium sulphate.

Sepatet al. (2012) evaluated the effect of Integrated Nutrient Management on growth, yield and quality of Tomato in trans Himalayan region. The treatment with 100% NPK + FYM + *Azotobacter* gave the best results for characters like cluster per plant (12.30), fruits per cluster (4.80), fruit size (6.30cm), fruit weight (116.7g), fruit yield per plant (1.62kg) and yield per hectare (12.70q/ha).

Chanda et al. (2011) checked the effect of Vermicompost and other fertilizers on the cultivation of Tomato plants at the Department of Zoology, Vidyasagar University Midnapore, WestBengal. The treatment with 50% Vermicompost + 50% chemical fertilizer NPK gave the best results for different yield attributes such as fresh weight of leaves (14.47g), dry weight of leaves (2.84g), dry weight of fruits (2.87g), number of branches (7.3), number of fruits per plant (19.95), weight of fruits (42.34g) and yield (338.7q/ha).

Javaria and Khan, (2011) at the Faculty of Agriculture, Gomal University, Dera Ismail Khan, Pakistan, examined the effect of Integrated Nutrient Management on soil environment, yield and quality of Tomato. Treatment 2 mg/ha FYM + 61kg N + 31kg P/ha showed best results for fruit yield per hectare (47t/ha), straw yield (12 mg/ha) and increase in yield (37.5%).

4.3 Qualitative characters

Manickam et al. (2022) evaluated the effect of different nutrient sources on productivity, profitability and quality of Tomato (*Solanum lycopersicum* L)at T.N.A.U. Coimbatore, Tamil Nadu. Maximum value of TSS (4.23^0B) and ascorbic acid (25.82mg/100g) was shown by treatment with 50% Nitrogen requirement through FYM + 50% Nitrogen requirement through Vermicompost whereas, highest titrable acidity (1.32%) was recorded by seedling treated with Ghanajeevamrit (250kg/ha) and Jeevamrit (500lt/ha) twice a month with irrigation water and 50% FYM + 50% Vermicompost.

Mishra et al. (2019) reported the effect of Organic Nutrient Management in Tomato under Randomized Block Design in two consecutive years at Orissa University of Agriculture and Technology, Orissa. Maximum TSS (5.36^0B) was found in the treatment with RDF (125:50:100 kg $N:P_2O_5:K_2O$/ha) which was at par with treatment having FYM @20t/ha (5.24^0B), Vermicompost @5t/ha as basal (5.08^0B) and poultry manure 2.5t/ha one year old (5.3^0B).

Meena et al. (2017) performed an experiment entitled the impact of biofertilizers on growth, yield and quality of Tomato (*Lycopersicon esculentum* Mill.) cv. Pusa Sheetal. Treatment with 100% Vermicompost recorded highest TSS (5.27^0B) whereas treatment with 75% RDF + 25% FYM + *Azospirillum* proved best for vitamin C (23.87mg/100ml).

Manohar et al. (2013) conducted an experiment on Integrated Nutrient Management in Tomato (*Lycopersicon esculentum* Mill.) cv. Rocky during summer season at Jaipur. Among different concentrations of FYM, FYM 20t/ha gave maximum chlorophyll content (6.79) and 100% RDF (NPK) + B +Zn responded for maximum chlorophyll content (6.71) among inorganic fertilizers.

In order to determine the impact of Integrated Nutrient Management on the growth, yield, and quality of Tomato in the trans Himalayan, Sepat et al. (2012) undertook an experiment over the course of two kharif seasons at Defence Institute of High Altitude Research, Dihar Det Partapur, Leh, and Ladakh. For the treatment with 100% NPK + FYM + *Azotobacter*, the highest qualitative traits, such as TSS value (5.40^0B), ascorbic acid (26.97mg/100g), and acidity (1.10%), showed to be the best.

Javaria and Khan, (2011) studied the impact of Integrated Nutrient Management on Tomato yield, quality and soil environment, and the results indicated that maximum value of pH (7.5) was recorded by $N_{120}P_{60}$.

4.4 Nutrient status

In order to determine how Integrated Nutrient Management affected the growth characteristics and soil nutrient status of Tomato grown in naturally ventilated polyhouses, Rajawat et al. (2019) conducted an experiment. According to the findings, the highest concentration of nitrogen was recorded in a treatment combination of 100% NPK RDF, followed by phosphorus (25.99 kg/ha) and potash (290.65 kg/ha) in a treatment combination of 100% organic management and NPK + biofertilizers.

Baba et al. (2018) studied the impact of *Azotobacter* and inorganic fertilizers on yield attributes of Tomato at farmer's field in village Wadura of Baramulla district of Jammu and Kashmir. The results of the study indicated that the highest Nitrogen % in fruit (0.32%) was recorded with treatment having *Azotobacter*-3 + PSB (PS6) + 100% NPK.

Kamal et al. (2018) carried out a study entitled the effect of Biofertilizers on growth and yield of Tomato (*Lycopersicon esculentum* Mill). The biofertilizers used were *Azotobacter*, *Azospirillum*, PSB and VAM. Treatment with PSB (Phosphorous Solubilizing Bacteria) and RDF recorded highest fresh weight of plant (639.33g) and dry weight per plant (129.00g).

Tekale et al. (2017) assessed the Integrated Nutrient Management (INM) on nutrient availability, uptake and yield of Tomato (*Lycopersicon esculentum* Mill.) cv. "Gujarat Tomato-2". They observed that maximum value of nutrient in soil harvest (255, 259 and 257 kg/ha), P_2O_5 (63.5, 61.9 and 62.7 kg/ha), K_2O 327, 322 and 325 kg/ha); total nutrient uptake N (136, 145 and 140 kg/ha), P (45.2, 49.8 and 47.5 kg/ha), K (66, 76 and 71 kg/ha) and nutrient content in tomato plant N (1.54, 1.56 and 1.55%), P_2O_5 (0.49, 0.50 and 0.50%); K_2O (1.30, 1.33 and 1.32%) were recorded by the treatment FYM 20t/ha + 100% FYM.

Javaria and Khan, (2011) conducted a study entitled impact of Integrated Nutrient Management on Tomato yield, quality and soil environment. The results indicated that maximum value of organic carbon (0.65%) and total nitrogen (0.08%) were recorded by $N_{90}P_{45}$ + N_{30} (wheat straw).

4.5 Benefit: cost ratio

The impact of various nutrient sources on the productivity, profitability, and quality of Tomato (*Solanum lycopersicum* L.) was studied by Manickam et al. in 2022. The findings showed that seedlings treated with Beejamrit + Ghanajeevamrit with the application of 50% FYM + 50% Vermicompost produced the highest gross profits (Rs. 299288/ha), net earnings (Rs. 183844/ha), and benefit: cost analysis (2.59).

Mishra et al. (2019) studied the Organic Nutrient Management in Tomato, for two consecutive years and concluded that highest net return (Rs.90424/ha) and maximum Benefit: cost ratio (2.22) was recorded by treatment poultry manure @5t/ha (one year old) as basal dose.

Singh et al. (2016) conducted an experiment to know the impact of Integrated Nutrient Management on Tomato yield under farmer's field condition at KVK Kandhamal, Orissa, India. They found thatmaximum benefit: cost ratio (4.39 and 4.29) was recorded in rabi and kharif season with FYM (10t/ha) followed by 1% *Azotobacter* and foliar spray with 20ppm ferrous ammonium sulphate than control conditions.

Pandey and Chandra (2012) carried out field trials to assess the impact of Integrated Nutrient Management on Tomato yield under farmer's field conditions at Chandauli, UP. Maximum Benefit: cost ratio of 4.23 and 4.25 was observed under treatment with FYM (10t/ha) + NPK (150:80:60 kg/ha) by dipping roots of seedlings with 1% *Azotobacter* and 20ppm ferrous ammonium sulphate.

Javaria and Khan, (2011) conducted a study for the impact of Integrated Nutrient Management on yield, quality and soil environment of Tomato at the Faculty of Agriculture, Gomal University, Dera Ismail Khan, Pakistan. Treatment with cow dung + ½ N_{200} + P_{35} + K_{80} + S_{15} recorded the highest benefit: cost ratio (4.38).

5. Technical Programme

5.1 Title –Evaluation of organic fertilizers as Integrated Nutrient Management practice in Tomato (*Solanum lycopersicum* L) under open field conditions.

5.2 Experimental Methodology-

1. Name of the crop	-	Tomato
2. Location	-	Research Station, Chhapang, Baru Sahib (H.P.)
3. Plot size	-	2.1m × 1.8m
4. Spacing	-	90cm × 30cm
5. Date of sowing-		
• **For 1st year**	-	4th April, 2023
• **For 2nd year**	-	Tentatively first week of April 2024
6. Date of transplanting-		
• **For 1st year**	-	9th May, 2023
• **For 2nd year**	-	Tentatively first week of May 2024
7. Hybrid of Tomato	-	Heem Sohna
8. Number of treatment combinations	-	25
9. Replications	-	3
10. Number of plots	-	75

11. **Number of plants/plot** - 14
12. **Design of the experiment** - Randomized Block Design
13. **Rate of application-**
    1. FYM - 25tons/ha
    2. Vermicompost - 5tons/ha
    3. Neem cake - 2tons/ha
    4. *Azospirillum* - 400g/ha
    5. *Azotobacter* - 400g/ha
    6. PSB - 400g/ha
    7. *Trichoderma* - 400g/ha
    8. VAM - 400g/ha
    9. NPK (19:19:19) - 150kg/ha

5.3 Treatment Combinations

Treatments	Treatment Combination
T_1	Absolute Control
T_2	FYM + 100% NPK (Standard check)
T_3	FYM
T_4	Vermicompost
T_5	Neem cake
T_6	*Azospirillum*
T_7	*Azotobacter*
T_8	PSB
T_9	*Trichoderma*
T_{10}	VAM
T_{11}	FYM + 50% NPK
T_{12}	Vermicompost + 50% NPK
T_{13}	Vermicompost + 100% NPK
T_{14}	Neem cake + 50% NPK
T_{15}	Neem cake + 100% NPK
T_{16}	*Azospirillum* + 50% NPK
T_{17}	*Azospirillum* + 100% NPK

T_{18}	*Azotobacter* + 50% NPK
T_{19}	*Azotobacter* + 100% NPK
T_{20}	PSB + 50% NPK
T_{21}	PSB + 100% NPK
T_{22}	*Trichoderma* + 50% NPK
T_{23}	*Trichoderma* + 100% NPK
T_{24}	VAM + 50% NPK
T_{25}	VAM + 100% NPK

5.4 Observations to be recorded

5.4.1 Vegetative parameters

5.4.1.1 Days to Ist flowering (Days after sowing): It will be recorded as the number of days required by six tagged plant in each plot to reach flower initiation or anthesis of first flower after transplanting and then the average will be calculated.

5.4.1.2 Days to 50% flowering(Days after sowing): The amount of time needed will be calculated as how many days pass between the day of transplanting and the day that 50% of the plants in each plot start to blossom.

5.4.1.3 Days to Ist picking: It shall be noted how many days pass in each plot between the transplanting date and the first harvest.

5.4.1.4 Number of nodes per plant: It will be determined as the total number of tagged plants' main stem nodes in each plot, and the average value will be noted.

5.4.1.5 Internodal length (cm): Measure the distance between two nodes from tagged plants of each plot with the help of measuring scale or measuring tape and average shall be recorded.

5.4.1.6 Plant height (cm): From the ground up to the plant's tip, starting with the tagged plants, it will be measured with the aid of a scale. Calculating the mean value is required.

5.4.1.7 Plant spread (cm): With the aid of a measuring tape, the plant vigor of six tagged plants from each plot was measured in the East-West and North-South directions, and the average value was recorded.

5.4.1.8 Leaf area (cm^2): By using graph paper, leaf area will be measured.

5.4.2 Quantitative parameters

5.4.2.1 Harvest duration (days): Calculate the number of days from the day of the first harvest to the last harvest of the six selected plants of each plot.

5.4.2.2 Fruit weight (g): The weight of fruit will be measured with the help of weighing balance. Average fruit weight will be calculated from each plot.

5.4.2.3 Fruit length (cm): The fruit length of six randomly chosen fruits from each plot will be measured with a digital Vernier caliper, and the average value will be determined.

5.4.2.4 Fruit girth (cm): The breadth of fruits harvested from each module will be measured with the help of digital Vernier caliper. The mean of six fruits per plot will be calculated.

5.4.2.5 Fruits per cluster: Two to three clusters from tagged plants of each plot will be counted to find the fruits per cluster.

5.4.2.6 Fruits per plant: Total number of fruits will be counted from each tagged plant of each plot and average value shall be calculated.

5.4.2.7 Yield per plant (g): The sum total of fruit weight of each tagged plants of each plot will be obtained from each picking and then the value will be pooled to work out the average yield per plant.

5.4.2.8 Yield per plot (kg/m^2): The total fruits harvested from each plot will be weighed and recorded to work out fruit yield/ plot.

5.4.2.8Yield per ha (q/ha): The fruit yield per plant in grams will be converted in to yield per hectare in quintal.

5.4.3 Qualitative parameters

5.4.3.1 TSS (^{0}Brix): With the help of Digital Refractometer we will calculate the value of TSS from each tagged plant of each plot.

5.4.3.2 Titrable acidity (%): It will be determined by AOAC official method (AOAC, 2000).

$$\text{Titrable acidity} = \frac{V \times 0.1 \times 1000 \times 0.064}{m}$$

Where, 0.1- Normality of NaOH (N)

0.064- conversion factor for citric acid

V- Volume of NaOH required (ml)

m- Mass of tomato juice sample used (g)

5.4.3.3 Lycopene (mg/100g): The lycopene content is measured by using Rapid Spectrophotometric method. In which the reagents like petroleum ether, 5% sodium sulphate and acetone will be used. In this method fruits will be crushed with a blender. 5-10g of pulp is mixed with acetone until the residue is colorless. Using the separating funnel mix the acetone extract and 20 ml petroleum ether. After adding 5% sodium sulphate solution, shake the funnel gently. Most of the color will be in the upper petroleum

ether layer. Collect it and make the volume up to 100 ml. Using petroleum ether as a blank, measure the absorbance at 503 nm with a spectrophotometer.

Absorbance (1 unit) `= 3.1206 µg lycopene/ml

Lycopene content (mg/g) = $\frac{3.1206 \times \text{absorbance}}{Weight\ of\ sample\ (g)}$ × dilution factor

5.4.3.4 Carotenoids (mg/100g): The carotenoids will be calculated as per the method suggested by Ranganna (1995).The sample is extracted with acetone and then transferred to a separating funnel containing petroleum ether. Color absorbance at 452 nm is compared to a 3% acetone blank.

$$\text{µg of carotene per 100 gm} = \frac{\text{Conc. of carotene in solution x final volume x dilution}}{\text{Weight of sample}} \text{ x100}$$

5.4.3.5 Phenolic content (mg/100g): The total phenolic content will be determined by using the Folin-Ciocalteu reagent (Thimmaiah, 1999) and following a slightly modified method of (Ainsworth and Gillespie, 2007).

5.4.3.6 Ascorbic acid (mg/100g): The content of ascorbic acid is determined by 2-6 dichlorophenol tenol visual titration method (A.O.A.C, 2005). We prepare the standard ascorbic acid with 50 ml metaphosphoric acid reagent. Then 1ml of this solution is used to standardize the dye which appears light pink in color. It referred to as endpoint and the dye factor is calculated as,

Dye factor = $\frac{mg\ of\ ascorbic\ acid}{ml\ of\ dye\ used}$

Ascorbic acid is extracted by crushing 5ml of sample with 25ml of 3% metaphosphoric acid. The extract is filtered and made to an appropriate volume. The appropriate allequate is titrated against 2-6 dichlorophenol tenol until a pink colour appeared. Ascorbic acid is calculated in mg/100 g pulp.

$$\text{mg of Ascorbic Acid per 100g/100 ml} = \frac{\text{Titre} \times \text{Dye factor} \times \text{Volume made up} \times 100}{\text{Aliquot of extract taken for estimation} \times \text{Weight of sample taken for estimation}}$$

5.4.3.7 Antioxidant activity (DPPH Radical Scavenging Assay): The DPPH (1, 1-diphenyl-2-picrylhydrazyl) radical scavenging impact will be analyzed with the method given by Bouaziz et al. (2008).

5.4.3.8 Pericarp thickness (mm): The fruits will be cut transversely and the pericarp thickness is measured with the help of digital Vernier caliper.

5.4.3.9 Chlorophyll content (mg/g): It will be measured with the help of spectrophotometer.

5.4.3.10 Mineral content: With the help of AOAC, 1990 system, mineral content will be estimated. The samples will be digested H_2SO_4 (18.01mol/L), HNO_2 mixture (14.44mol/L) and $HClO_4$ (11.80mol/L), using AAS (Atomic Absorption Spectroscopy).

5.4.3.11 Shelf life (days): Shelf life of the tomato will be determined by counting the number of days till the fruits will remain acceptable for marketing as suggested by Moneruzzaman et al. (2009).

5.4.4 Nutrient and soil parameters

5.4.4.1 Initial and final status of NPK (Kg/ha)

5.4.4.1.1 For Nitrogen: It will be measured by alkaline $KMnO_4$ method given by Subbiah and Asija, 1956.

In this method about 10kg of soil is mixed with excess of alkaline $KMnO_4$ and distilled. Distillation is done by using a known volume of standard sulphuric acid. Due to which the ammonia gas which is released by distillation is absorbed and excess of the gas is titrated with standard alkali. Methyl red is used as an indicator.

Available Nitrogen Kg/ha = (X-Y) × 31.36

Where,

X (ml) = Volume of N/50 H_2SO_4 taken

Y (ml) = Volume of N\50 NaOH used

5.4.4.1.2 For Phosphorous: Available phosphorous is estimated by using Olsen's method (Olsen et al. 1954)

Available phosphorous in soil is extracted by shaking the soil with 0.5M sodium bicarbonate soledon. Later on it is involved in the formation of chlorostannous which is reduced molybdophospheric blue color. On a spectrophotometer, readings are taken at a wavelength of 68 nanometers. The curve is drawn using observations on the vertical axis and the concentration of P in ppm on the horizon axis.

Available P (kg/ha) = Z_1-Z_2 × 100 (d.f) × 2.24

Where,

Z_1 = ppm P obtained from graph by using X

Z_2 = ppm P obtained from graph by using Y

X = Spectrophotometer reading of soil sample

Y = Spectrophotometer reading of blank sample

$$d.f = \frac{Volume\ of\ extractant\ taken}{Weight\ of\ soil}\ x\ \frac{Final\ volume\ of\ extract}{Volume\ of\ extract\ taken}$$

2.24 = Conversion factor for converting ppm into kg/ha

5.4.4.1.3 For Potassium: By flame photometer

We will take 5g of soil, added 25 ml N neutral ammonium acetate solution. Then filter the contents using Whatman No. 1 filter paper. Feed the flame to flame photometer after the proper setting and calibration. Blank is run without soil.

Available K kg/ha = R × 5(dilution factor) ×2.24

Where,

R = ppp (k) as obtained by standard curve

X = Reading of flame photometer

$$\text{Dilution factor} = \frac{25\ (Volume\ of\ extractant)}{5\ (Weight\ of\ soil)}$$

5.4.4.2 Fresh weight of plant (g): Using a weighing balance, the complete plant (chosen tagged plants) is weighed at the time of uprooting the trial, along with the roots, and the average will be recorded.

5.4.4.3 Fresh weight of fruit (g): At the last harvest, fruits of tagged plants will be selected and weighed in weighing balance.

5.4.4.4 Dry weight of plant (g): After drying the fresh plants in the oven for 2-3 hours at 60-65^{o}C temperature. The weight of the dried plant will be taken.

5.4.4.5 Dry weight of fruit (g): Fruits are dried in the oven at 60-65^{o}C for 2-3 days until they loose their moisture content and then the weight of fruits will be taken. The mean value of tagged plants is taken.

5.4.4.6 Nutrient uptake of NPK in plant (%)

5.4.4.6.1 Leaf sample collection and preparation: During the second harvest of the crop, composite leaf samples are collected from entirely grown leaves. Leaf samples are cleaned using Chapman's (1964) method after being washed with distilled water. Before being placed in paper bags and dried for 48 hours in a hot air oven set to 65°C, the samples were spread out on filter paper to allow for air drying. To determine the N, P, and K contents, crush the dried samples, make a powder, and store it in polythene bags.

5.4.4.6.2 Digestion of the leaf sample: A well-grounded samples of known weight, produced in a 4:1 combination of concentrated HNO_3 and $HClO_4$, will be digested in a mixture of diacides for the nutrients of P and K. The Nitrogen Estimate utilizing concentrated H_2SO_4 and a digestive combination is carried out according to Jackson (1973).

5.4.4.6.3 Plant biomass: Weighing the plant, including its roots and fruits, yields an estimate of its biomass. Following the final harvest, the plant, roots, and fruits will be dried for 72 hours in an oven at 60- 65°C before being weighed. Plant biomass is defined as the dried plants weight. The biomass of plants is measured in grams (g).

5.4.4.6.4 Dry matter: Following harvest, the randomly chosen plants from each replication will be dried in a ventilated laboratory oven. Each sample is independently ground with a laboratory mill after drying at a temperature of 50 to 55^0C until the weight of the samples remained consistent during intervals of 12 hours.

The dry matter will be calculated using the following formula:

Dry matter (per cent) = 100 - $\frac{m1-m2}{m} \times 100$

Where, m1 = weight of the sample before drying with the laboratory tray

m2 = weight of the sample after drying with the laboratory tray

m = weight of the analyzed sample before drying

5.4.4.7 pH of soil: A pH meter will be used to measure the pH of the soil.

5.4.4.8 Electrical conductivity of soil (dS/m): It will be measured by using a device called an Ohmmeter. It measures the resistance of a substance to the flow of current.

5.4.4.9 Organic carbon (%): Organic carbon will be estimated with the help of titration method (Walkley and Black, 1934).

Organic carbon (%) in soil= $\frac{10(B-S)}{B} \times 0.003 \times \frac{100}{wt.of\ sample\ (g)}$

Where, B and S stand for the titre value (ml) of blank and sample, respectively.

5.4.5 Benefit: cost ratio- The following procedure will be used to calculate the B.C. ratio for each module.

$$\text{Net returns (Rs/ha)} = \frac{\text{Gross returns – Cost of cultivation (Rs/ha)}}{\text{Cost of cultivation (Rs/ha)}}$$

$$\text{B:C ratio} = \frac{Net\ return}{Cost\ of\ production}$$

5.5 Statistical analysis- Each replication's values for every observation will be examined using a Randomized Block Design analysis. The following analysis of variance is recommended by Gomez & Gomez (1983)

Table no. 2 Analysis of variance

Source of variation	Degree of freedom	Sum of square	Mean sum of square	F value
Treatments	t-1	S_t	S_t / t-1	M_t/M_e
Replication	r-1	S_r	S_r/ r-1	M_r/M_e
Error (e)	(t-1) (r-1)	S_e	S_e / (t-1) (r-1)	M_e

Where: r = Number of replications

t = Number of treatments

Me = Error variance

We will compare the F computed value and the F tabulated value. The standard error and critical difference will be estimated to assess if one therapy is better than the other under each replication if the F test revealed a significant result.

The standard error and critical difference is calculated as:

$$SE(m) \pm = \sqrt{\frac{Me}{R}}$$

$$SE(d) \pm = \sqrt{\frac{2Me}{R}}$$

$CD_{0.05}$ (LSD) = SE (d) × t value at error degree of freedom

Where,

SE(m) ± = Standard error of mean

SE (d) ± = Standard error of difference

6. COLLABORATION (if any) (Nil)

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Signature of student